Don Lancaster's

Tech Musings

January, 2000

Working with newsgroups
Temperature measurements
Understanding "favicon.ico"
Thermocouple fundamentals
A Gambler's Ruin simulation

We sure seem to have lots of superb new ways to sense temperature lately. *Dallas Semiconductor* has all sorts of low cost, linear, self-conditioning single chip solutions. Ones that work very well over "normal" temperatures in "friendly" environments. Some log or store their own data.

A few examples now include their DS1621, DS1624, and DS1820. Details on these and similar offerings from *Analog Devices*, *Holtek*, *National*, or *Maxim*, *Philips*, *Toko*, and others can be found at *www.questlink.com* or at *www.chipcenter.com* These sites also offer ap notes and samples.

But there are times when you need to measure extreme temperatures. Or are stuck with a nasty environment. Or have to reuse older industrial test gear. For these uses, the traditional *thermocouples* are still often a good choice. So, we seem to be way past due for an introductory…

Thermocouple Review

If two dissimilar metals or alloys are placed in contact with each other, the *Seebeck Effect* generates a small voltage. One that is dependent upon absolute contact temperature.

For instance, copper contacting a constantan alloy will generate around seven millivolts at room temperature. Voltage increases by 40 microvolts per degree C or so as the temperature changes. Your voltage versus temp is fairly linear. Especially over limited ranges. Much of your remaining nonlinearity is well known, is stable, monotonic, and easily corrected.

A *thermocouple* is simply a sensor or a probe made from two dissimilar metals or alloys that are in contact with each other. Figure one shows a typical thermocouple setup. Long ago and far away, thermocouples were used in *pairs*. The first sensor in the series bucking pair was placed in an *ice bath* and the temp *difference* was sensed. In most new systems, a *cold reference* of a few millivolts is often substituted instead.

At one time, amplifiying an offset microvolt sized dc signal was a bear of a problem. But we now have got single chips that can do the whole job from *Analog Devices*, *Dallas*, *Linear Technology*, *Maxim* and others. That make this task hassle free.

Because any two contacting metals do generate a thermoelectric voltage, you have to be extra careful how you connect your thermocouple to your system. The simplest and safest is to use identical conductor materials all the way through. Every time you add a connector or new conductors, you add unwanted thermoelectric offsets.

All of these *must* get properly and fully accounted for.

Thermoelectric potentials are all compared against lead. Figure two shows you the microvolts per degree you can expect from various common materials. Along with the first order linearity correction. To find how any junction behaves, add up the positive and negative lead results.

Using these figures should tell you that a cold junction compensated type "T" copper-constantan thermocouple should output…

-5.54 millivolts at -200 C
-3.35 millivolts at -100 C
+0.00 millivolts at 0 C
+4.28 millivolts at 100 C
+9.29 millivolts at 200 C
+14.9 millivolts at 300 C
+20.9 millivolts at 400 C

As you can see, the linearity seems pretty good but not great. The easiest way to correct is with table lookup read out of EEPROM. That exciting *Maxim* MAX1457 and its offspring do seem especially adept at this.

Because tin has low thermoelectric potentials, solder will behave pretty much the same as pure lead.

There are several different popular thermocouples in general use. These differ in their output voltage, their useful temperature range, their lead color coding, linearity, stability, and the types of chemical environments they must survive in. A few of these are summarized in figure three.

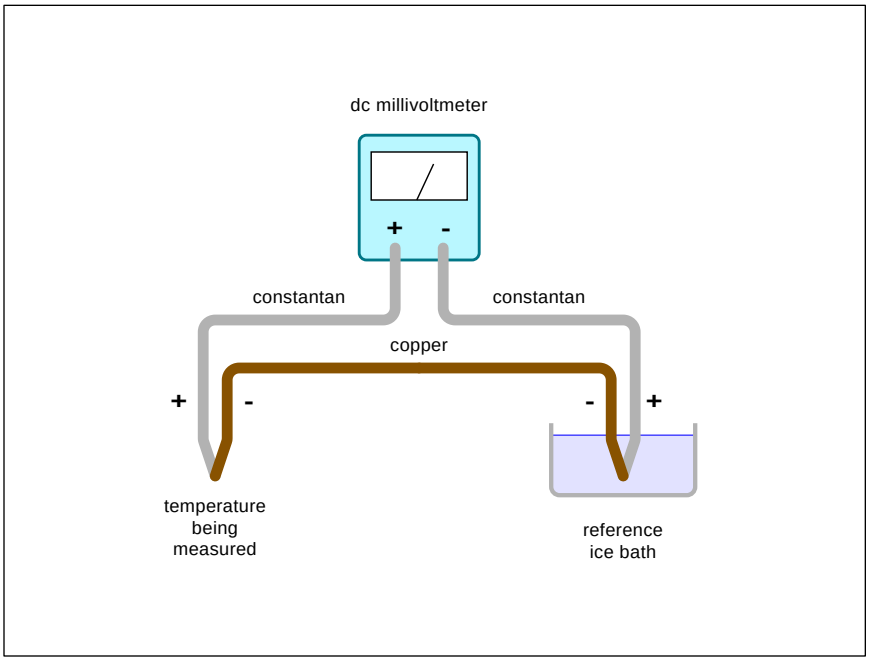

Fig. 1 – THERMOCOUPLE TEMPERATURE MEASUREMENT makes use of the Seebeck Effect to create millivolt sized signals proportional to temperature differences. The traditional "cold junction" shown here is usually replaced with a small and precise voltage reference.

MATERIAL	uV/DEG	NONLIN	MATERIAL	uV/DEG	NONLIN
Aluminum	-0.38	-0.00010	Lead	0.0000	0.0000
Antimony	+35.58	+0.145	Magnesium	-0.201	+0.002572
Bismuth	-43.68	-0.465	Mercury	-8.81	-0.0333
Brass	+0.710	+0.00561	Nickel	-19.067	-0.03022
Cadmium	+3.059	+0.0285	Nichrome	+25.0	+0.02643
Carbon	+11.056	+0.0358	Palladium	-7.409	-0.03922
Cobalt	-10.71	-0.0570	Platinum	-3.038	-0.03248
Constantan	-38.105	-0.0888	Rubidium	-8.26	-0.0302
Copper	+2.76	+0.0122	Silicon	-408.2	-0.4696
Germanium	+302.5	+0.725	Silver	+2.50	+0.0115
Gold	+2.90	+0.0068	Tin	+0.0684	+0.000038
Indium	+2.40	+0.00190	Tungsten	+1.594	+0.0341
Iron	-51.34	-0.204	Zinc	+3.047	-0.0099

Fig. 2 – THERMOVOLTAGES generated by popular metals and alloys.

The type "J" thermocouple is the most popular one for everyday apps, while the type "T" gives you the best stability and performance for lower industrial on down to liquid nitrogen cyrogenic temperatures. A type "K" thermocouple might be a good choice for a high temperature kiln.

A big hidden gotcha that will nail you every time: US thermocouples have *red* as their *negative* lead!

Watch this detail.

Your fundamental thermoelectric properties are found in the *Handbook of Chemistry and Physics*. Details in *www.tinaja.com/amlink01.html* Trade journals are *Measurement & Control* or *Sensors*. *Sensors & Actuators B* is one scholarly journal.

Thermocouple costs go from a few to several hundred dollars, depending on their type and use environment. Figure four shows us a stainless steel immersion unit.

A leading supplier is *Omega*, and *Watlow* is a second. Useful tutorials can be picked up on their respective *www.omega.com/temperature* and *www.watlow.com/ref/index.html* web sites. Good stuff here.

Another useful tutorial website is found up at *www.engr.orst.edu/~aristopo/temper.html*

I've got lots of type "T" premium long leaded lower temperature range thermocouples, precision thermistors, temp color strips, and *Fluke* digital temperature instrument bargains up at *www.tinaja.com/barg01.html*

The **Type B** thermocouple has 30% platinum / rhodium as its (+) grey lead and 6% platinum / rhodium as its red (-) lead. It is easily contaminated and requires careful protection. It is used at higher temperatures from +1400 to +1700 degrees C (+2500 to +3500 F).

The **Type C** thermocouple has a tungsten 5% rhenium as its (+) lead and tungsten 26% rhenium as its (-) lead. It works at extremely high temperatures but has no oxidation resistance. Needs vacuum, hydrogen, or intert atmospheres. +1650 to +2315 C (+3000 to +4200 F).

The **Type E** thermocouple has a chromel (+) purple lead and a constantan (-) red lead. It has the highest output of base metal thermocouples and does not corrode at cyrogenic temperatures. +95 to +900 C (+200 to +1650 F).

The **Type J** thermocouple has an iron (+) white lead and constantan as its (-) red lead. This is the most popular general use thermocouple, but can "rust" in oxidizing environments. +95 to +760 C (+200 to +1400 F).

The **Type K** thermocouple has chromel as its (+) yellow lead and alumel as its (-) red lead. This is a good kiln thermocouple in oxidizing atmospheres. +95 to +1260 C (+200 to +2300 F).

The **Type N** thermocouple has Nicrosil as its orange (+) lead and Alumel as its red (-) lead. Resists sulfur. Also kiln usable. +650 to +1260 C (+1200 to +2300 F).

The **Type R** thermocouple has platinum 13% rhodium as its (+) black lead and pure platinum as its (-) red lead. For high temperature oxidizing atmospheres but easily contaminated. +870 to +1450 C (+1600 to +2640 F).

The **Type S** thermocouple has platinum 10% rhodium as its (+) black lead and pure platinum as its (-) red lead. A lab standard but easily contaminated. +980 to +1450 C (+1800 to +2640 F).

The **Type T** thermocouple has constantan as its (+) blue lead and copper as its red (-) lead. It is the most stable at liquid nitrogen cyrogenic temperatures and useful from -200 to +350 degrees C (-330 to +660 F).

Fig. 3 – SOME PROPERTIES of popular thermocouple junctions.

Thermoelectric Power?

Can thermocouples or *thermopiles* be used to generate power? Well, sort of. But these are so inefficient that they are limited to very special uses. Using today's known materials, any bunch of thermocouples grouped to recover, say, exhaust heat from a car would never come remotely near to getting back all of the energy used in manufacture. Let alone being able to pay for themselves.

But thermoelectrics can rarely be applied for "Uh, compared to what?" needs for modest quantities of power. On an arctic expedition ferinstance. Or for precision power measurement. Or to generate enough current from a gas flame to run a safety shutoff.

There is a second thermoelectric response known as the *Peltier Effect*.

This applies a bulk carrier migration property of bismuth telluride or other special semiconductors. These rarely see use for cooling devices. Again, these are hopelessly inefficient with known materials. Restricting them to the most arcane of low power uses.

More on the Peltier effect is found in RATHOLES.PDF

Some Thermoelectric Books

I've gathered together some books about thermocouples, thermoelectics, and about temperature measurement in general for you as this month's resource sidebar. You can find more details or order these titles by going to *www.tinaja.com/amlink01.html*

The Gambler's Ruin

A novel little simulation program called *the gambler's ruin* appears as a PostScript-as-language example in figure four. Suppose you and I start with ten coins each and run a "fair" coin flipping game till somebody has all the coins. Who wins?

On the average, you would expect to win half of the time. Now, we will make a seemingly minor change. The house starts with 100 coins and the mark has only 10.

Now who wins?

Surprisingly, the mark now wins less than ten percent of the time. If the house starts with 10,000 coins, the mark *never* wins! At least not so as you'd ever notice.

The mark may temporarily get way ahead, but they *never* win. The point being that any mark who bets against everything that can be gambled on is absolutely *certain* to lose big time.

This model plays out two million games. Every thousand games, your mark's winnings are reported to the PS log file as a percentage. You can easily change each side's coin starts or the number of games.

As usual, you enter your program in any word processor or editor and then route it to *Acrobat Distiller* or *GhostScript*. The ready-to-run code is at *http://www.tinaja.com/post01.html*

favicon.ico ?

The tiniest details seem to make a profound difference between a good web site and a great one. I was using my GRAB404.PS log error snooper at *www.tinaja.com/weblib01.html* and recently began picking up all sorts of 404 *file not found* errors on a strange beastie called *favicon.ico*.

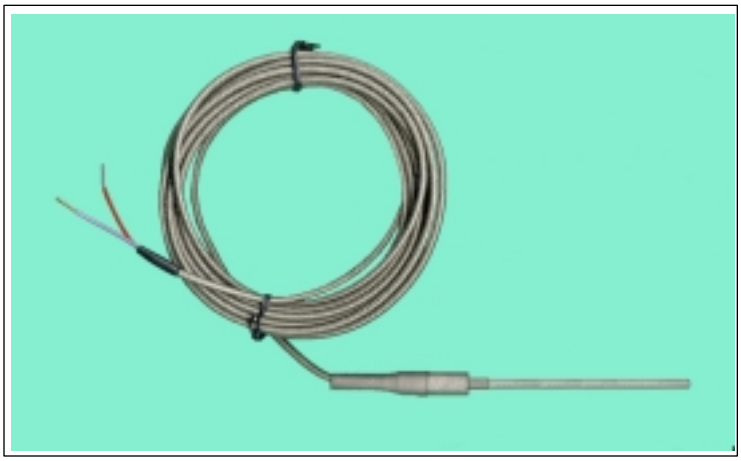

Fig. 4 – A TYPICAL THERMOCOUPLE.

It turns out these were folks trying to save my site as one of their Win98 favorites. Apparently you'll have to give them a 16x16 bitmapped icon named *favicon.ico* to let this happen. A web search using the *hotbot* button on my web page turned up all sorts of useful favicon utilities.

The one I ended up using was the interactive online Java service up at *www.favicon.com* The process is fun, quick, and simple. You create an icon online in real time using their *Paint* style pixel editor. They then email it back to you. Free.

You do have to make certain it is renamed *favicon.ico* and FTP it to

```
% THE "GAMBLER'S RUIN" IN POSTSCRIPT
% ====================================

% Copyright c 2000 by Don Lancaster and Synergetics, Box 809, Thatcher, AZ, 85552
% (520) 428-4073 don@tinaja.com or http://www.tinaja.com
% Consulting services available per http://www.tinaja.com/info01.html

% All commercial rights and all electronic media rights fully reserved.
% Personal use permitted provided header and entire file remains intact.
% Linking is welcome. Reposting expressly forbidden.

% This PostScript-as-language example simulates the "gambler's ruin".
% It shows how bet outcomes change dramatically when one side has got
% significantly more resources than the other.

/win 0 def                                      % mark's wins
/loss 0 def                                     % mark's losses
/housecoins 100 def                             % house initial stake
/markcoins 10 def                               % mark initial stake

/random {rand 65536 div 32768 div mul cvi} def  % as in -- 6 random --

/play {markcoins {2 random                      % flip coin
1 ge {1 add}{1 sub} ifelse                      % adjust mark's stash
dup 0 lt {pop /loss loss                        % exit if loss
1 add store exit}if
dup markcoins housecoins add gt                 % exit if win
{pop /win win 1 add store exit}if
        }loop} def                              % play till win or lose

2000 {                                          % start 2,000,000 play loop
1000 { play} repeat                             % play 1000 games
win loss win add div                            % find mark's wins
100 mul ==  flush                               % convert to percent
      } repeat                                  %      and then report

% In this example, the mark should win just under 10% of the time.
```

Fig. 5 – THE "GAMBLER'S RUIN" simulation written in PostScript.

SOME SELECTED THERMOMETRY BOOKS

CRC Handbook of Thermoelectrics (D.Rowe)
Electronic Refrigeration (H. Goldsmid)
Fundamentals of Temperature Measurement (Robert Benedict)
Handbook of Temperature Measurement (Robin Bentley)
Industrial Temperature Measurement (Thomas Kerlin)
Measurement of Temperature and Humidity (W. Wylie)
Measurements in Flames (J. Chedaille)
Practical Thermocouple Thermometry (Thomas W. Kerlin)
Principles of Temperature Measurement (Thomas McGee)
Temperature Measurement (Amer Society for Testing)
Temperature Measurement (Bela Liptak)
Theory and Properties of Thermocouple Elements (D. Pollock)
Thermocouple Temperature Measurement (P.Kinzie)
Thermoelectric Materials (Marshall Sittig)
Thermoelectric Materials 1998: The Next Generation (T. Tritt)
Thermoelectricity: Theory, Thermometry, Tools (D. Pollock)
Use of Thermocouples in Temperature Measurement (ASTM)

For more book details, see ***www.tinaja.com/amlink01.html***

your website. Note that any icon file errors might cause your users serious problems, so it is best to use a free service of this type.

Thoughts on Newsgroups

I'm still amazed how many of my helpline callers still have never heard of Usenet *newsgroups* and do not tap this highly useful resource.

A newsgroup is an unmoderated special interest chat room. There are many tens of thousands of these to pick from. Examples of newsgroups that I personally use are…

comp.lang.postscript
comp.systems.apple2
comp.text.pdf
sci.electronics.misc
sci.electronics.design
sci.electronics.repair
sci.electronics.equipment
sci.energy.hydrogen
sci.engineering.lighting
sci.math
sci.optics
sci.physics

Newsgroups are useful for helping newbies. Or solving strange problems or matching up buyers and sellers for arcane equipment. Or for picking up all the secret insider stuff of software bugs, defects, or gotchas.

There are several methods to find newsgroups. Your ISP might already offer these in their basic service to you. Or may charge a nominal (0.50 to $3) monthly surcharge. If you are using an ISP, just click on Netscape Mail's *Subscribe* to generate a list of 18,000 or more groups. Then click on any of the groups you might find of interest. Finally, double check on the traffic and make sure the content and usefulness are as you thought.

Alternately, you might make good use of *www.deja.com/home_ps.shtml* for a newsgroup access. This service also archives everything that has ever been said about anything. While Deja is more ungainly than direct access, it should easily reach even the most obscure of groups.

Deja is also especially useful to tell you which groups may be of help to you. The answer often is already there. Or to scope out what another newsgroup author's *posting history* has been. Deja is also conveniently reached from my DEJA button over at *www.tinaja.com*.

You can also start your own Deja forum. Details are on their site.

Since anybody can participate, the quality varies all over the lot. Some newsgroups yield nothing but porno links and really dumb get rich quick schemes. Others rarely get above the intellectual level of some fifth grade playground brawl. Yet others simply do not have nearly enough traffic to be worth bothering with.

Direct selling or blatantly obvious promotion are both no-no's on most newsgroups. Especially when they're also off topic. Unless their name ends in *".marketplace"*.

There are secret incantations that insiders use to sell their stuff without offending too many people. If you preceed your message with AN:, this is an *announcement* of a product or service that is available. FS: handles *for sale* and the new FA takes care of auctions. Especially *eBay*.

It is also usually permissible to add a commercial "please visit" tagline in the message or in your sig file.

But keep everything super short.

Several tips: *Never* respond to any person who is using some alias or is hiding their true address. Several of these individuals seem clearly a few chips shy of a full board. Should you offend them, at least a few have been known to anonymously tell your boss about all your outstanding kiddyporn warrants. Sad but true.

Use *Deja News* to make sure you are not asking something which has already gotten answered many times. Think about all your messages before you post them. Always double check your spelling. *Pause before clicking!* Always ask yourself the key question "My message is now going into Deja News where it will stay forever. Do I really want to do this?"

Never use binary files or any other attachments of any sort. If you need more content, use links instead.

Always respond to your group and *never* to the individual. For the group can be influenced, but the individual often can not. Be sure to let the other side post the last message.

Always ignore flamers (those who seem rude or insulting) and the trolls (those intentionally using outrageous posts to yank your chain).

NEED HELP?

Phone or email all your US Tech Musings questions to:

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US email: *don@tinaja.com*
Web page: *www.tinaja.com*

NAMES AND NUMBERS

Advanced Circuits
21100 E 33rd Sr
Aurora CO 80011
(800) 289-1724
www.4pcb.com

Allegro Micro Systems
Box 15036
Worcester MA 01605
(508) 853-5000
www.allegromicro.com

Analog Devices
PO Box 9106
Norwood MA 02062
(800) 262-5643
www.analog.com

Dallas Semiconductor
4401 Beltwood Pkwy S
Dallas TX 75244
(972) 450-0400
www.dalsemi.com

Disc Makers
7905 N Crescent Blvd
Pennsauken NJ 08110
(800) 237-6666
www.discmakers.com

Fibersense/Fog Horn
755 Dedham St
Canton MA 02081
(781) 830-9690
www.fibersense.com

Holtek/Holmate Technology
1342 Ridder Park Dr
San Jose CA 95131
(408) 573-8050
www.holtek.com

Linear Technology
1630 McCarthy Blvd
Milpitas CA 95035
(408) 432-1900
www.linear-tech.com

Maxim
120 San Gabriel Dr
Sunnyvale CA 94086
(800) 998-8800
www.maxim-ic.com

Micrel Semiconductor
1849 Fortune Drive
San Jose CA 95131
(408) 944-0800
www.micrel.com

Microchip Technology
2355 W Chandler Blvd
Chandler AZ 85224
(480) 786-7200
www.microchip.com

National Semiconductor
2900 Semiconductor Rd
Santa Clara CA 95052
(800) 272-9959
www.national.com

Omega Engineering
One Omega Dr
Stamford CT 06907
(800) 848-4286
www.omega.com

Philips
2001 W Blue Heron Blvd
Riveria Beach FL 33404
(407) 881-3200
www.philips.com

Pressurex/SPI
188 Rt 10, Ste 307
East Hanover NJ 07936
(800) 755-2201
www.sensorprod.com

Stemgas Publishers
PO Box 328
Lancaster PA 17608
(717) 392-0733

Synergetics
Box 809
Thatcher AZ 85552
(520) 428-4073
www.tinaja.com

Toko
1250 Feehanville Drive
Mt Prospect IL 60056
(847) 297-0070
www.tokoam.com

Watlow Controls
12001 Lackland Rd
St Louis MO 63146
(800) 4-WATLOW
www.watlow.com

Wavetek
11995 El Camino Real #301
San Diego CA 92130
(619) 793-2300
www.netsv.com/wavetek

Repeated responses should rarely exist at all. But, if you feel you must, *always* take these offline and make use of private email instead.

The first way to deal with flamers and trolls is to use your killfile. Or simply by *never* so much as reading anything they post. The second is a sneaky trick I call *deraveling a troll*. In which you will let somebody else respond to the thread, then respond to the respondee. But carefully *remove* any and all previous mention of the troll or their points. Redirecting the thread into benign and informative group tutorial material, useful links, or whatever else works.

A second useful troll defense is to *strengthen the middle*. Post factual relevant mainstream info. Especially

news and lots of solid references. Do so often. Which makes the sideshows painfully obvious. Eventually, all of the two-headed calves should leave of their own accord.

Note that extreme politeness and professional decorum is *demanded* in most *.sci* newsgroups. The intent of *.sci* groups is to *purposely* seek out criticism and negative comment.

Iffen yew cain't hunt with the big dawgs, stay on the porch.

It is also wildly inappropriate to post off-the-wall pseudoscientific or other unsupportable claims to any *.sci* group. All this does is confirm that you are a total idiot. Use an *.alt* group (such as *alt.energy.hydrogen*, *alt.sex.sheep* or *alt.energy.overunity*) instead. Where hogwash is welcome.

More on newsgroups can be found in RESBN60.PDF, and RESBN73.PDF.

New Tech Lit

Microchip Technology has recently started up a retail online store. Which once and for all eliminates hassles in getting their great PIC chips, however obscure. Go to *www.microchip.com* for full details.

As we have seen before, just about any newer semiconductor sample can be gotten at *www.questlink.com* or at *www.chipcenter.com*. You can reach these both through the buttons on my *www.tinaja.com* website.

From *Toko*, two new data books on *Power Conversion IC's* and *Coils & Filters*. From *Allegro Microsystems*, a new CD ROM data book on lots of Hall devices and interface circuits.

From *Micrel* their new MIC502 fan management chip. And from *Analog Devices* their *New Products Update* condensed data book.

One useful far infrared tutorial site is *www.intrel.com* For HDTV info, *web-star.com/hdtv/hdtvnews1.html*

The website for that *Pyrotechnics Guild International* can be found at *www.pgi.org/html* You should get a real bang out of this one.

From *Advanced Circuits* a promo CD on their printed circuit production capabilities. CD ROM manufacturing info is available from *Disc Makers*. Including all those new business card size 250 Megabyte CD's.

Details on fiber optic gyros appear in the free and aptly named *Fog Horn* mag from *Fibersense Technology*.

Stemgas Publishers offers a wide variety of books and other tricky to find info on steam tractors and other antique ag machinery.

From *Sensor Products* a new line of *Pressurex* Tactile pressure films. Their stuff changes color whenever you stress it. Making for all sorts of great mechanical studies. Ranges go from 28 to 18,500 psi.

For most individuals and smaller scale startups most of the time, any involvement with patents is virtually certain to end up as a net loss of your time, energy, money, and sanity. Do find out why along with my tested and proven solutions in my *Case Against Patents* package. As per my *Synergetics* ad. Or you can check out *www.tinaja.com/patnt01.html*.

Just added a whole load of really fine *Wavetek* 145 function generators, premium accelerometers, and robotic electric brakes to my bargain pages at *www.tinaja.com/barg01.html* To get "cash-and-carry" tech research help, do visit *www.tinaja.com/info01.html*

As usual, most of the referenced items are in our *Names & Numbers* or *Thermometry Books* sidebars. Be sure to check here first before calling our no-fee US tech helpline. ✦